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# STOPOVER ON A GULF COAST BARRIER ISLAND BY SPRING TRANS-GULF MIGRANTS

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ABSTRACT.—Neotropical passerine migrants were studied when they stopped on a barrier island along the coast of Mississippi following spring trans-Gulf migration. Peak numbers of migrants occurred from mid-April through early May 1987. Males of several species arrived earlier than females, suggesting that females initiated spring migration later. When migrants stopped on Horn Island they used Scrub/Shrub, Pine Forest, and Relic Dune habitats more than expected if they were distributed independently of habitat type. Scrub/Shrub habitat was characterized by the greatest number of species, the highest species diversity, and the largest number of individuals. Migrants foraged alone or in small flocks usually composed of a single species. Birds were preyed upon during stopover, suffered starvation when they stopped in an energetically stressed condition, and succumbed to adverse weather during migration. Stopover areas must be viewed as important links in species' annual cycle if the conservation of migratory passerines is to be successful. *Received 30 Aug. 1989, accepted 1 Dec. 1989.*

Decline in populations of Neotropical passerine migrants is a serious conservation problem (Keast and Morton 1980, Rappole et al. 1983); one that may be linked to habitat loss on the wintering grounds (e.g., Robbins et al. 1989) or fragmentation of forested breeding habitat (e.g., Wilcove 1988, Holmes and Sherry 1988). A third factor that affects migrant populations is the availability of suitable en route habitat, where the energy reserves critical to a successful migration can be replenished rapidly and safely. When neotropical migrants stopover after crossing the Gulf of Mexico (Rappole and Warner 1976, Moore and Kerlinger 1987), the woodlands and wooded barrier islands along the northern Gulf coast provide the last possible foraging opportunity before fall migrants cross the Gulf of Mexico and the first potential landfall for birds returning north in spring. They provide a place to deposit energy reserves before fall migrants undertake a nonstop flight (18–24 h) of >1000 km, and they give spring migrants a place to rest and replenish reserves following trans-Gulf flight.

We first describe briefly the pattern of arrival of neotropical passerine migrants that stop during spring migration on Horn Island, a barrier island along the northern coast of the Gulf of Mexico. Because sex-related differences in time-of-arrival on the breeding grounds are widespread among

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passerine migrants (e.g., Francis and Cooke 1986), we also examine arrival dates of males and females for several species. Second, we describe habitat use by spring migrants on Horn Island. The suitability of stopover habitat influences the rate of which migrants replenish energy reserves, how long they interrupt migration to stay at a site, opportunities to choose suitable sites later in migration (see Piersma 1987), and ultimately the migrant's survival and reproductive success. We follow Hutto's (1985) definition of habitat as ". . . a spatially contiguous type that appears more or less homogeneous throughout and is physiognomically distinctive from other such types." Third, we report on the flocking behavior of migrants during stopovers on Horn Island following trans-Gulf migration. Sociality may provide both feeding and anti-predator advantages for migratory birds (Morse 1977, Pulliam and Millikan 1982) during stopover in unfamiliar habitat. Fourth, we identify sources of mortality associated with trans-Gulf migration. Adverse weather is a major cause of mortality (e.g., Ligon 1968, Whitmore et al. 1977) and small passerines are at risk when crossing water barriers (e.g., Saunders 1907, Cooke in Chapman 1907, Paynter 1953, Bullis 1954, James 1956). Migrants are also vulnerable to predation, especially when energy considerations assume priority (e.g., Metcalfe and Furness 1984, Kerlinger 1989, Lindstrom 1989).

## STUDY AREA AND METHODS

Horn Island is one of more than 50 barrier islands that border the northern Gulf of Mexico (Fig. 1). As a federally designated wilderness area in the Gulf Islands National Seashore, it is the least disturbed barrier island in the Gulf of Mexico. Located approximately 14 km from the Mississippi coast, the 1400-ha island ranges in width from several hundred meters to just over 1 km and is 22 km long. A variety of aquatic and terrestrial habitats include 60 permanent ponds and lagoons and uplands ranging from intertidal sand flats to vegetated dunes > 10 m in elevation (Eleuterius 1979). We identified five plant habitats during this study. The percent of the island occupied by a particular habitat, after excluding barren sand and open water (25% of total island area), is noted parenthetically in the following descriptions.

*Primary Dune* (14.4%) borders the inter-tidal zone on both sides of the island and is dominated by *Uniola paniculata* and *Andropogon maritimus. Marsh/Meadow* (28.9%) habitat is dominated by expansive stands of *Juncus roemerianus, Spartina alterniflora,* and *S. patens* in tidal flood areas, or *Fuirena scirpoidea, Panicum repens,* and *Andropogon virginicus* in fresh water areas, with occasional shrubs (*Baccharis halimifolia* and *Myrica cerifera*) and living and dead slash pines (*Pinus elliotti*) along the edges. *Scrub/Shrub* (14%) consists of shrub thickets, which range to 5 m in height, that are dominated by *B. halimifolia* and *M. cerifera* on wetter sites and by *Ilex vomitoria,* dwarf live oak (*Quercus geminata*), and *Serenoa repens* on drier sites. *Relic Dune* (28.8%) refers to high, dry relic dune ridges characterized by sparse low shrubs, *Solidago pauciflosculosa, Ceratiola ericoides,* the rock-rose *Helianthemum arenicola, Opuntia* cactus, and a few emergent slash pine and dwarf live oak. *Forest* (13.9%) habitat consists of a slash pine canopy, with small numbers of *Quercus geminata* and an understory that ranges from open on drier sites to dense thickets of *Myrica, Baccharis,* and *Ilex* on wetter sites.

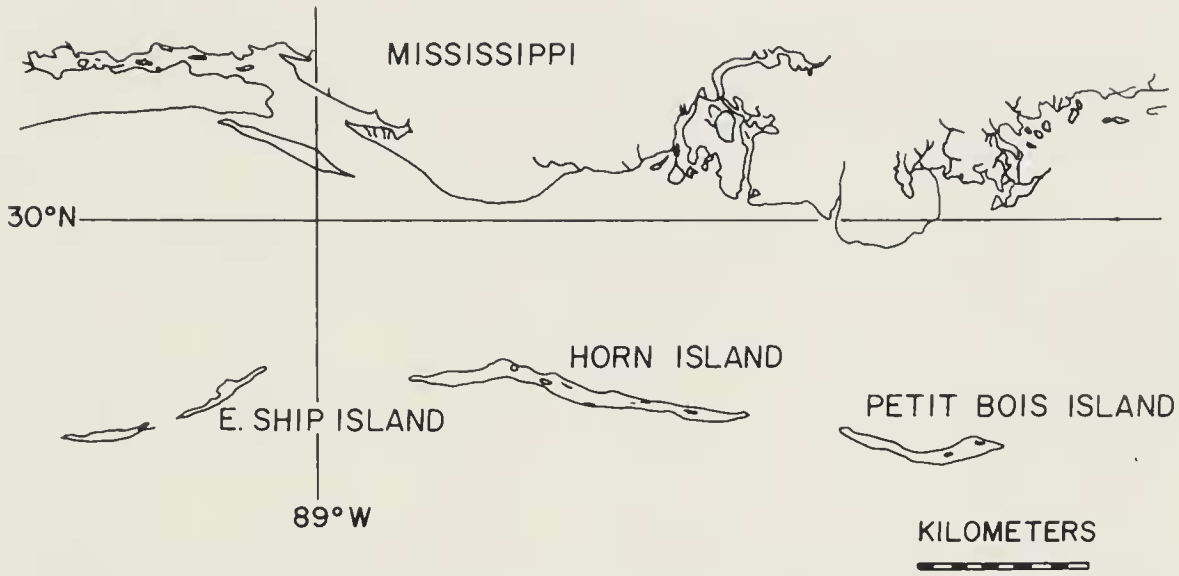


FIG. 1. Map showing barrier islands along the northern coast of the Gulf of Mexico. Sampling sites are located on Horn Island.

The bird species observed in this study were intercontinental migrants that winter in the Caribbean basin, Central America, and South America and breed in temperate North America. All but Ruby-throated Hummingbirds (*Archilochus colubris*) and Yellow-billed Cuckoos (*Coccyzus americanus*) were passerines. Point counts were used to estimate the number of species stopping on the island and to provide an index of abundance. No effort was made to estimate the absolute density of the migrants that stopover on the island. Sampling points were established at 50-m intervals along three transects that passed through each of the five habitats. A point within each habitat type along the three transects was selected randomly (three points per habitat) and counts conducted twice daily in each habitat type: once in the morning (07:30–10:00 CST) and once in the afternoon (15:30–18:00 CST). The order of daily visitation to habitat types was randomized. At each stop, the observer recorded all birds seen within that habitat type during a 10-min period, although only individuals perched, foraging, or displaying aggressive behavior were included in the analysis of habitat use. Association with a flock while foraging was noted as well as whether the flock was mixed or homospecific. Observations were made daily 21 March to 9 May 1987 in Primary Dune, Marsh/Meadow, Forest, and Scrub/Shrub habitats. Relic Dune was added as a habitat type on 10 April.

## RESULTS

*Pattern of arrival.*—Although the number of species stopping on Horn Island following trans-Gulf migration varied daily, species numbers increased in mid-April and averaged about 25 spp./day until the end of the study. The cumulative number of species increased rapidly during mid-April, after which the rate slowed. The number of individuals that arrived on the island also varied from day to day, although peak numbers were evident during late April through the second week in May.

Males appeared earlier than females among the eight species for which we have adequate samples (Table 1). The arrival of the first female was

TABLE 1

ARRIVAL OF MALES (M) AND FEMALES (F) ON HORN ISLAND DURING SPRING 1987 FOR 8 SPECIES OF SEXUALLY DIMORPHIC TRANS-GULF MIGRANTS

| Species[a] | First dates by sex | | M:F 1st 10 birds[a] | N[b] (% M) |
|---|---|---|---|---|
| Black-and-white Warbler[c] | M—3/24 | F—3/24 | 19:2 | 57 (61) |
| Hooded Warbler | M—3/24 | F—4/02 | 10:0 | 98 (67) |
| Prothonotary Warbler | M—3/25 | F—3/28 | 15:1 | 110 (73) |
| Ruby-throated Hummingbird | M—3/26 | F—3/31 | 18:4 | 224 (55) |
| Summer Tanager | M—3/27 | F—4/08 | 14:6 | 128 (66) |
| Orchard Oriole | M—3/29 | F—4/12 | 10:0 | 185 (54) |
| Indigo Bunting | M—4/12 | F—4/14 | 11:1 | 160 (70) |
| Rose-breasted Grosbeak | M—4/13 | F—4/18 | 16:1 | 92 (74) |

[a] The number of males may have exceeded 10 because several individuals were usually observed on the day that the cumulative number of birds reached 10.

[b] Sample sizes greater than those given in Table 2 because (1) only individuals observed feeding or perched are counted in Table 2 and (2) individuals observed before 10 April are not included in Table 2.

[c] Scientific names given in Table 2.

at least two days later than the first male in seven of eight species. The overall sex ratio for all eight species was skewed toward males. Females may be under-sampled because of differential detectability, although males and females of seven species for which we have adequate samples (Ruby-throated Hummingbird, Scarlet and Summer tanagers [scientific names not given in the text are listed in Table 2], Black-and-white Warbler, Prothonotary Warbler, Orchard Oriole, and Indigo Bunting) used similar habitats on the island ($\chi^2$ analyses, $P > 0.05$).

*Habitat use.*—Our analysis of habitat use was divided into two parts based on the pattern of trans-Gulf migration during spring 1987. Before 10 April few migrants stopped on the island (N = 135 or 9% of the total number of migrants observed during this study). Most trans-Gulf migration occurred after 10 April, which coincided with the addition of Relic Dune as a fifth habitat type. Trans-Gulf migrants were distributed unequally among habitats before and after 10 April, although sample sizes were not sufficient to permit species comparisons prior to 10 April. Nevertheless, a one-way ANOVA of individuals of all species indicated significant variation in the mean number of detections during the early period of trans-Gulf migration, and a Tukey's multiple range test (Zar 1984) separated Scrub/Shrub habitat from the other types. A second ANOVA (after 10 April) yielded comparable results. Whereas migrants used Primary Dune and Marsh/Meadow habitats significantly less often than the other habitat types, Tukey's test failed to distinguish between use of Forest and Relic Dune and between Relic Dune and Scrub/Shrub habitats after

TABLE 2

THE PERCENTAGE OF OBSERVATIONS IN EACH OF FIVE HABITAT TYPES BY SPRING TRANS-GULF MIGRANTS THAT STOPPED ON HORN ISLAND BETWEEN 10 APRIL AND 13 MAY 1987. PERCENT OCCURRENCE AMONG FIVE HABITAT TYPES DEVIATES SIGNIFICANTLY FROM EXPECTED FOR EACH SPECIES ACCORDING TO CHI-SQUARE ANALYSES

| Species[a] | Scrub/shrub | Primary dune | Marsh/ Meadow | Pine forest | Relic dune | Total N |
|---|---|---|---|---|---|---|
| Yellow-billed Cuckoo *Coccyzus americanus* | 47% | — | — | 20% | 33% | 45 |
| Ruby-throated Hummingbird *Archilochus colubris* | 47 | 1 | 21 | 5 | 26 | 128 |
| Great-crested Flycatcher *Myiarchus crinitus* | 46 | — | 2 | 48 | 4 | 84 |
| Eastern Kingbird *Tyrannus tyrannus* | 15 | 11 | 56 | 10 | 7 | 174 |
| Veery *Catharus fuscescens* | 49 | — | — | 43 | 8 | 43 |
| Swainson's Thrush *C. ustulatus* | 46 | 2 | — | 46 | 6 | 58 |
| Wood Thrush *Hylocichla mustelina* | 60 | — | — | 32 | 8 | 25 |
| White-eyed Vireo *Vireo griseus* | 77 | — | — | 14 | 9 | 49 |
| Red-eyed Vireo *V. olivaceus* | 51 | — | 1 | 34 | 13 | 119 |
| Tennessee Warbler *Vermivora peregrina* | 76 | — | — | 2 | 22 | 55 |
| Yellow Warbler *Dendroica petechia* | 41 | — | — | 7 | 52 | 39 |
| Black-and-white Warbler *Mniotitla varia* | 81 | — | — | 13 | 6 | 31 |
| Prothonotary Warbler *Protonotaria citrea* | 76 | — | — | 4 | 20 | 45 |
| Hooded Warbler *Wilsonia citrina* | 77 | — | — | 19 | 4 | 37 |
| Summer Tanager *Piranga rubra* | 45 | — | 9 | 34 | 13 | 65 |
| Scarlet Tanager *P. olivacea* | 40 | — | 15 | 29 | 16 | 75 |
| Rose-breasted Grosbeak *Pheucticus ludovicianus* | 44 | — | 3 | 31 | 23 | 39 |
| Blue Grosbeak *Guiraca caerulea* | 15 | 2 | 7 | 15 | 61 | 47 |
| Indigo Bunting *Passerina cyanea* | 26 | — | 1 | 24 | 49 | 126 |
| Orchard Oriole *Icterus spurius* | 43 | — | 22 | 7 | 28 | 106 |
| % Area occupied by each habitat type | 14% | 14.4 | 28.9 | 13.9 | 28.8 | 100 |
| Total individuals[b] | 609 (682) | 25 (26) | 177 (181) | 290 (309) | 289 (301) | 1390 (1499) |
| Total species[b] | 20 (43) | 4 (4) | 10 (13) | 20 (36) | 20 (28) | 20 (46) |

[a] Species for which fewer than 25 individuals were sighted are not included in habitat breakdown.
[b] Total number of individuals and number of species, regardless of sample size, are noted parenthetically.

TABLE 3

RESULTS OF SINGLE FACTOR ANOVA FOR THE DISTRIBUTION OF NEOTROPICAL MIGRANTS PRIOR TO 10 APRIL AND THE PEAK OF SPRING TRANS-GULF MIGRATION (FOUR HABITAT TYPES) AND AFTER 10 APRIL (FIVE HABITAT TYPES) ON HORN ISLAND, 1987

| Source of variation | SS | df | MS | *F* |
|---|---|---|---|---|
| <10 April | | | | |
| Total | 3771.86 | 27 | | |
| Between groups | 2361.29 | 3 | 787.10 | 13.39 |
| Within groups | 1410.57 | 24 | 58.77 | $P < 0.001$ |
| >10 April | | | | |
| Total | 37,625.32 | 80 | | |
| Between groups | 15,025.28 | 4 | 3756.32 | 11.30 |
| Within groups | 22,600.03 | 76 | 332.35 | $P < 0.001$ |

10 April (Table 3). Chi-square analysis of the frequency of occurrence of all individuals after 10 April leads to a similar conclusion: Scrub/Shrub, Forest, and Relic Dune were used more by migrants than Primary Dune and Marsh/Meadow. A greater number of species (Table 2) was recorded for the three former habitats. Scrub/Shrub habitat, which represented 14% of available habitat (16% after excluding Primary Dune), was characterized by the greatest number of species, the highest species diversity, and the largest number of individuals (Table 2). More than twice the number of individuals (N = 682) were seen in Scrub/Shrub than any other habitat, and three times more than the number expected if migrants are distributed independent of habitat type. Of the 46 species observed in the study, 94% were seen in Scrub/Shrub, 78% in Forest, 60% in Relic Dune, and only 37% were seen in Marsh/Meadow and Primary Dune. Only six or seven species should be found in Scrub/Shrub habitat if they are distributed independently of habitat type.

Where sample sizes permit analysis, species-specific habitat use patterns are evident (Table 2). Eastern Kingbirds, for example, were the only migrants to use Primary Dune during stopover and one of a few species to use Marsh/Meadow habitat, where 56% were recorded. Whereas migrants were observed in Relic Dune (Table 2), only Yellow Warblers, Blue Grosbeaks, and Indigo Buntings occupied this habitat more frequently than expected if they were distributed independently of habitat type. More than 75% of the sightings of Black-and-white, Hooded, Tennessee, and Prothonotary warblers and of White-eyed Vireos were in Scrub/Shrub

habitat. Several other species were found in Scrub/Shrub habitat more often than any of the other four habitat types (Table 2).

Contingency analysis indicates that the distribution of individual migrants differs between morning and afternoon samples, whether Primary Dune habitat was included or not ($\chi^2 = 76$, $P < 0.001$; $\chi^2 = 67$, $P < 0.001$, respectively). The number of migrants in Scrub/Shrub, the habitat used most often, was less than expected in the afternoon, yet more than expected in the morning when over 50% of all migrants were detected there. The distribution of species among the five habitat types did not differ between morning and afternoon samples.

*Flocking.*—During "fallouts," when large numbers of migrants landed on the island over a short period of time, birds moved quickly from tree-top to tree-top or shrub to shrub among habitats, often in loose mixed-species flocks, giving the impression that they were assessing habitats prior to making a choice. There did not appear to be a directional bias to these movements. Movement among habitats declined sharply within one hour of a fallout.

Once migrants "settled" in a habitat, they often foraged alone. Flocks were small and usually were composed of a single species (Table 4). Tennessee Warblers, Indigo Buntings, and Orchard Orioles, which rarely foraged alone (i.e., less than 25% of the observations), were invariably associated with homospecific groups. Rose-breasted Grosbeaks and Swainson's Thrushes were always observed in homospecific groups when flocked. Although both tanager species were observed more often foraging alone, they also formed homospecific groups. The only migrants that occurred in mixed-species flocks more often than homogeneous groups were Black-and-white Warblers and White-eyed Vireos. Red-eyed Vireos, on the other hand, formed single-species flocks, and the majority of those groups consisted of two individuals.

Groups of two were common among several other species during stopovers on Horn Island (Table 4). Among single-species flocks of sexually dimorphic species, heterosexual pairs occurred no more often than expected on the basis of the number of males and females observed ($P > 0.05$). Other single-species groups were seldom larger than three or four individuals (see Table 4) and usually consisted of both sexes. Even among Orchard Orioles and Indigo Buntings, average flock size was less than five.

*Source of mortality.*—We identified three sources of mortality associated with spring trans-Gulf migration and stopover on Horn Island: (1) death during a trans-Gulf flight, (2) starvation during stopover following trans-Gulf flight, and (3) predation by raptors. The remains of 66 indi-

TABLE 4

FLOCKING TENDENCY (MIXED- AND SINGLE-SPECIES) AMONG NEOTROPICAL MIGRANTS DURING STOPOVER ON HORN ISLAND FOLLOWING TRANS-GULF MIGRATION IN SPRING 1987. AVERAGE SIZE OF SINGLE-SPECIES FLOCKS IS GIVEN FOR SEVERAL SPECIES

| Species | N[a] | % of N alone | Single-species flocks | | | |
|---|---|---|---|---|---|---|
| | | | %[b] | No. groups[c] | Ave. size | Pairs[d] |
| Yellow-billed Cuckoo | 39 | 82% | 86% | 3 | | 3 |
| Veery | 40 | 75 | 80 | 3 | | 1 |
| Swainson's Thrush | 55 | 56 | 100 | 10 | 2.4 | 7 |
| Wood Thrush | 25 | 80 | 80 | 2 | | 2 |
| White-eyed Vireo | 46 | 48 | 25 | 3 | | 3 |
| Red-eyed Vireo | 111 | 52 | 72 | 14 | 2.6 | 8 |
| Tennessee Warbler | 52 | 15 | 70 | 9 | 3.4 | 0 |
| Yellow Warbler | 33 | 48 | 76 | 6 | 2.2 | 5 (2) |
| Black-and-white Warbler | 26 | 54 | 17 | 4 | | 1 (1) |
| Prothonotary Warbler | 43 | 33 | 55 | 4 | | 0 |
| Hooded Warbler | 37 | 38 | 52 | 3 | | 0 |
| Summer Tanager | 64 | 58 | 81 | 8 | 2.8 | 4 (3) |
| Scarlet Tanager | 70 | 66 | 83 | 9 | 2.2 | 7 (5) |
| Blue Grosbeak | 47 | 62 | 72 | 4 | | 1 |
| Rose-breasted Grosbeak | 38 | 39 | 100 | 9 | 2.6 | 6 (2) |
| Indigo Bunting | 119 | 24 | 99 | 20 | 4.5 | 6 (3) |
| Orchard Oriole | 96 | 16 | 99 | 20 | 4.0 | 7 (4) |

[a] Number of observations.
[b] Percent of flock subtotal in single-species groups.
[c] Number of single-species groups observed.
[c] Percent of single-specics groups consisting of only two individuals. Number of male-female pairs noted parenthetically.

viduals of at least 18 species were discovered in the surf or on the beach during daily walks along a 2-km stretch of beach. This "sample" is a conservative indication of mortality because carcasses are consumed or buried by crabs or other scavengers. The most frequently found species (*Catharus* thrushes, Scarlet Tanagers) winter in South America and often arrive on the barrier islands in a fat-depleted condition (Kuenzi 1989).

Thirteen individuals of five species were found dead in the interior of the island, presumably of starvation: Purple Martin (*Progne subis*) (N = 7, mean mass = 34.6 g), Indigo Bunting (N = 3, mean mass = 9.5 g), Tree Swallow (*Iridoprocne bicolor*) (N = 1, mass = 12.2 g), Red-eyed Vireo (N = 1), and Hooded Warbler (N = 1, mass = 7.7 g). These masses are near fat-free values (Kuenzi 1989) and carcasses were devoid of visible subcutaneous fat (see Helms and Drury 1960). The remains of 12 individuals of at least five species were found on the island during the study period and had evidently been preyed upon by raptors. Although few

TABLE 5

RAPTORS OBSERVED ON HORN ISLAND BETWEEN 21 MARCH AND 10 MAY 1987

| Species | N[a] | No. individuals | Habitat | Dates (early/late) |
|---|---|---|---|---|
| Swallow-tailed Kite[b] *Elanoides forficatus* | 5 | 4 | Forest: in flight and hunting | 24 Mar/30 Apr |
| Northern Harrier *Circus cyaneus* | 3 | 3 | Marsh/meadow: in flight and hunting | 26 Mar/2 Apr |
| Sharp-shinned Hawk[c] *Accipiter striatus* | 13 | 12 | Forest: in flight | 26 Mar/26 Apr |
| Cooper's Hawk *A. cooperi* | 1 | 1 | Forest: in flight | 24 Mar |
| Red-tailed Hawk *Buteo jamaicensis* | 2 | 1 | Marsh/meadow: in flight and perched | 5 Apr/7 Apr |
| American Kestrel[d] *Falco sparverius* | 14 | 8 | Marsh/meadow and edge: in flight, hunting and perched | 29 Mar/25 Apr |
| Merlin[d] *F. columbarius* | 24 | 20 | Marsh/meadow, edge and forest clearings: in flight, hunting and perched | 22 Mar/9 May |
| Peregrine Falcon[d] *F. peregrinus* | 15 | 12 | Marsh/meadow and Dune: in flight, hunting and perched | 21 Mar/8 May |

[a] Number of sightings.
[b] Observed foraging extensively on insects (aerial capture).
[c] Observed chasing passerines (captures not observed, though evidence of successful prey capture was found).
[d] Observed chasing, capturing, and feeding on passerines.

instances of predation were observed, sightings of raptors on the island were numerous during migration and were associated most often with the Marsh/Meadow and Forest (pine) habitat types (Table 5). In the former habitat, those predators perched on isolated trees from where they watched for prey. Several Merlins and Peregrine Falcons spent consecutive days on the island, frequenting the same perches. Five of eight raptor species and 87% of 61 individual raptors observed during the study prey on small birds.

## DISCUSSION

Counts of birds on Horn Island during the spring of 1987 indicate that most trans-Gulf migration occurred from mid-April through early May, which coincides with seasonally favorable weather for crossing the Gulf of Mexico (Buskirk 1980). The seasonal pattern of trans-Gulf migration revealed in our study corroborates the pattern found by mist-netting migrants on an adjacent barrier island (Kuenzi 1989) and in coastal Lou-

isiana (Moore, unpubl. data) as well as radar observations made by Gauthreaux (1968) in coastal Louisiana.

Males of several species appeared on Horn Island before females in the spring of 1987. Francis and Cooke (1986) found that the difference between sexes among several paruline warblers at Prince Edward Point, Ontario, ranged from two to six days and differed most in species that arrived earliest. Although data more comparable to the Ontario study are needed from the northern Gulf coast before differential passage can be compared latitudinally, our results suggest that males depart earlier from neotropical wintering grounds rather than migrating at a faster rate than females (i.e., make fewer stopovers and/or stopover for a shorter time). If the latter were the case, the difference in time-of-arrival at stopover sites should increase as migrants approach breeding areas and should be minimal following trans-Gulf migration.

Our sample sizes probably reflect a surplus of males on the island. Because females cross the Gulf of Mexico later than males and because the probability of favorable weather for ongoing migration increases as the season progresses (Buskirk 1980), fewer females stopover on the island. Although females may be less conspicuous than males during stopover, the sexes do not appear to differ in the habitats they used on the island nor do sexes differ in microhabitat use (within habitats) during stopover (Moore pers. obs.).

*Habitat use.*—Habitat use during migration has profound consequences for a bird's: (1) ability to satisfy energy requirements, (2) vulnerability to predators, and (3) exposure to environmental stress. Migrants cannot search for the best stopover habitat (sensu Hutto 1985) and may be forced to use sub-optimal sites, especially after crossing an ecological barrier. Besides the availability of suitable habitat (Fretwell and Lucas 1970), habitat selection during migration depends on the time available to search for superior habitats (Ward 1987). For a fat-depleted migrant, the benefits of rejecting suboptimal habitats may be outweighed by the cost of failing to find the "best" habitat. Extrinsic (extra-habitat) factors, such as accessibility of stopover habitats, could override ranking of habitats based on within-habitat criteria such as food availability (Hutto 1985). For example, the peak of trans-Gulf migration occurs in the latter half of April and early May, and it corresponds to a period of strong southerly airflow with infrequent frontal activity (Buskirk 1980). Unfavorable weather associated with frontal activity (i.e., northerly winds and precipitation) occasionally extends south to the Gulf coast and into the Gulf of Mexico and forces migrants to "fallout" when and where they might not otherwise

stopover (Lowery 1955; Gauthreaux 1971, 1972; Moore and Kerlinger 1987).

Nevertheless, when trans-Gulf migrants stopover on Horn Island, they select certain habitats. In most cases, we can only speculate as to why certain habitats were attractive to migrants. The selection of open habitats by Eastern Kingbirds, for example, was probably related to the bird's propensity to hawk prey items (pers. obs.). Presumably Scrub/Shrub was attractive because it offered refuge from predators as well as adequate food. Moreover, we cannot conclude how specific are the implied preferences. Patterns of use extended across three widely used habitat types, though five of the 20 species included in Table 2 clearly preferred Scrub/Shrub. Because long-distance migrants make repeated and temporary use of stopover habitats that normally differ in vegetation structure, resource quality and quantity, and competitive pressures, flexibility in the use of habitat would be expected during migration. This flexibility provides the basis for immediate responses to the energy demands of migration (Morse 1971, Loria 1988).

Although habitat selection in areas of stopover may be innate (Bairlein 1983), identification of suitable habitat undoubtedly requires time for migrants to familiarize themselves with the distribution and availability of resources. Two observations suggest that migrants settle in a habitat according to some ranking based on exploration (see Hutto 1985): (1) When migrants first arrive they "stream" through habitats in loose mixed-species groups and seldom feed. Shortly thereafter, they are usually found foraging alone or in small single-species flocks. (2) The difference in habitat use we found between morning and afternoon samples suggests that migrants adjusted their use of habitat types following exploration. Because most trans-Gulf migrants arrived over the northern Gulf coast after 10:00 h (see Gauthreaux 1971, 1972) and because many of the birds that stopped during the day left the island the evening of their arrival (Moore and Kerlinger 1987, Kuenzi 1989), migrants observed during afternoon (pm) censuses are likely to be birds that arrived that day, whereas birds observed during morning (am) censuses are birds that spent at least one day on the island. Changes in habitat use over the course of a day might also reflect diel changes in prey availability (e.g., Hutto 1981) or energetic constraints. Lean birds might broaden their use of habitats in response to heightened energy demand much as they do microhabitat utilization (see Loria 1988).

*Flocking.*—Most passerines that cross the Gulf of Mexico initiate migration at night and reach the northern Gulf coast during daylight (Lowery 1955, Gauthreaux 1971). The diel timing of arrival on the northern Gulf

coast depends on wind and weather conditions over the Gulf of Mexico, with peak densities between 10:00 and 14:00 CST (Gauthreaux 1971). The majority of birds fly in compact flocks at an altitude of 1200 to 1500 m (Gauthreaux 1971) at that time and remain in flocks at stopover sites (Gauthreaux 1972, Rappole and Warner 1976).

Flocking could improve a migrant's chance of finding suitable habitat and adequate food. Once suitable habitat was located on Horn Island, many migrants foraged alone, while others continued to forage in small flocks. Our observations on the presence and behavior of bird-eating raptors on Horn Island suggests that predation is a significant risk to migrants and group foraging could decrease the probability of predation (Morse 1977, Pulliam and Millikan 1982; but see Lindstrom 1989). Less time spent scanning for predators and more time searching for food would be especially important for a fat-depleted migrant following trans-Gulf migration.

Flocks on Horn Island were usually small and homogeneous in composition. Although social foraging may enhance rates of food intake for migrants, the small flock sizes observed in our study may reflect a decrease in flocking tendency because food requirements are high relative to expected food intake (Pulliam and Millikan 1982). When fat-depleted migrants arrive on Horn Island, they are unfamiliar with the distribution and abundance of food, and expected food intake is unknown.

We often observed groups of two or three birds, including both sexes, which is consistent with speculation that some individuals form pairbonds prior to arrival on the breeding site (Greenberg and Gradwohl 1981). However, migrants are believed to fly singly or in loose groups at night (Balcomb 1977), which would make it difficult for pairs to remain together. Recent observations of "marked" Prothonotary Warblers suggest that trans-Gulf migrants may depart from the same location, maintain contact while flying at night, and form flocks the next morning over the northern Gulf Coast (Moore 1990).

*Mortality.*—Pienkowski and Evans (1985) observed that "[T]he remarkable lengths of regular migratory journeys by many birds are now so well established that some biologists seem to discount their costs." Mortality during migration, though difficult to estimate, may be substantial (Lack 1946, Moreau 1972, Ketterson and Nolan 1982). Our observations reveal that migratory birds are preyed upon during stopovers, suffer starvation when they stopover in an energetically stressed condition, and succumb to adverse weather during migration.

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